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DESIGN OF A PLANAR MONOPOLE ULTRA WIDE BAND PATCH ANTENNA

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ABSTRACT

This paper presents the design of an ultra-wide band (UWB) patch antenna with the microstrip line feed and also optimization of various antenna parameters. The antenna has been designed on a FR4 substrate with dielectric constant $\varepsilon r = 4.4$, loss tangent ($\tan \delta$) = 0.002. The antenna has been optimized to obtain UWB characteristics from frequency range 3.1 GHz to 10.6 GHz. The simulation results gives the satisfactory antenna parameters over the entire frequency band. The reflection coefficient of the optimized microstrip patch antenna is below -10 dB over the entire frequency band. VSWR is also < 2 over the entire frequency range. The radiation pattern of the designed antenna is nearly omni-directional in H-plane and bi-directional in E-plane. The proposed antenna has been simulated using CAD FEKO 6.2 EM Simulator using MoM (Method of Moment). The antenna presents in this paper provides a brief idea of Ultra Wide Band RSMA. The designed antenna is comparatively smaller in size, low cost and can be used for the various UWB applications.

KEYWORDS: Patch Antenna, UWB, Radiating Patch, Ground Plane, Method of Moment

INTRODUCTION

In recent years, the current trend in commercial and government communication system has been to developed low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a large spectrum of frequencies. This technological trend has focused much effort into the design of Micro strip patch antennas. With simple geometry patch antennas offer many advantages not commonly exhibited in other antenna configurations. For example, they are extremely low profile, light weight, simple and inexpensive to fabricate using modern day printed circuit board technology, compatible with microwave and millimeter wave integrated circuits (MMIC), and have the ability to confirm to planar and non planar surfaces. In addition, once the shape and the operating mode of the patch are selected, designs become very versatile in terms of operating frequency, polarization, pattern and impedance. The variety in design that is possible with Micro strip antennas probably exceeds that of any other type of antenna element.

In February 14, 2002, the Federal Communication Commission (FCC) allocated a bandwidth of 7.5GHz, i.e. from 3.1GHz to 10.6 GHz to UWB applications for unlicensed use [1]. The feasible design and implementation of UWB system has become a highly competitive topic in both academy and industry communities of telecommunications due to its advantage of high data rate (more than 100 Mb/s) over short ranges, large information capacity, low cost and low power consumption, etc. The UWB antenna has an increased attention due to its impedance bandwidth, simple structure and omnidirectional radiation pattern. [2]

Ultra Wideband is defined as any communication technology that occupies greater than 500 MHz of bandwidth, or greater than 25% of the operating centre frequency [1]. Most narrowband systems occupy less than 10% of the centre frequency bandwidth, and are transmitted at far greater power levels. For example, if a radio system is to use the entire UWB spectrum from 3.1-10.6 GHz, and centre about almost any frequency within that band, the bandwidth used would have to be greater than 100% of the centre frequency in order to span the entire UWB frequency range. By contrast, the 802.11b radio system centres about 2.4 GHz with an operating bandwidth of 80 MHz This communication system occupies

a bandwidth of only 1% of the centre frequency.

MOTIVATION FOR ULTRA WIDEBAND ANTENNA

UWB has a substantial effect on antenna design. Given that antenna research for most narrowband systems is relatively mature, coupled with the fact that the antenna has been a fundamental challenge of the UWB radio system.[3]. UWB has piqued a surge of interest in antenna design by providing new challenges and opportunities for antenna designers. The main challenge in UWB antenna design is achieving the wide impedance bandwidth while still maintaining high radiation efficiency. Spanning 7.5 GHz, almost a decade of frequency, this bandwidth goes beyond the typical definition of a wideband antenna. UWB antennas are typically required to attain a bandwidth, which reaches greater than 100% of the centre frequency to ensure a sufficient impedance match is attained throughout the band such that a power loss less than 10% due to reflections occurs at the antenna terminals [4]. Aside from attaining a sufficient impedance bandwidth, linear phase is also required for optimal wave reception, which corresponds to near constant group delay.

This minimizes pulse distortion during transmission. Also, high radiation efficiency is required especially for UWB applications. Since the transmit power is so low (below the noise floor), power loss due to dielectrics and conductor losses must be minimized. Typically, antennas sold commercially achieve efficiencies of 50-60% due to lossy dielectrics. A power loss of 50% is not acceptable for UWB since the receive end architecture already 12 must be exceptionally sensitive to receive a UWB signal. Extra losses could compromise the functionality of the system. The physical constraints require compatibility with portable electronic devices and integrated circuits. As such, a small and compact antenna is required. A planar antenna is also desirable.Given that there are several additional constraints and challenges for the design of a UWB system antenna, motivation for antenna design is clear.

ANTENNA DESIGN

For the design and for the optimization of parameters we are using CAD-FEKO tool with Method of Moment (Mom).

Method of Moment

In the method of moment, the surface currents are used to model the micro strip patch and volume polarization currents in the dielectric slab are used to model the fields in the dielectric slab. An integral equation is formulated for the unknown currents on the micro strip patches and the feed lines and their images in the ground plane. The integral equations are transformed into algebraic equations that can be easily solved using a computer. This method takes into account the fringing field outside the physical boundary of the two dimensional patch thus, providing a more exact solution.

The design process started with the selection of the suitable shape for patch. After selection, calculations for the antenna dimensions will be carried out to determine the size of the antenna. Then, the antenna performance, that is the re-turn loss measurement will be analyzed using CAD-FEKO, if the results is not as desired modifications were made to the patch. The port location that gave the best performance to antenna would be determined using CAD-FEKO. Antennas that fulfill the desired characteristics were produced and the real return loss measurements will be carried out. If the antenna matches the requirements then the design process stops here and the antenna polar pattern will be examined. If the antenna did not fulfill the requirements then the design process will start again from the computer analysis to improve the design. FEKO is a Method of Moments (MoM) tool that can be used to calculate the radiation pattern, impedance and gain of an antenna while mounted on some defined geometry. In addition, it can calculate the isolation or mutual coupling between pairs of antennas, the near fields around an antenna and the electric currents that flow on an antenna or the

surrounding structure.

The geometry of the proposed antenna is shown in Figure 1 and Figure 2

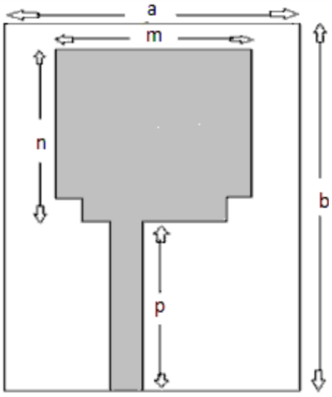

Figure 1: Top View

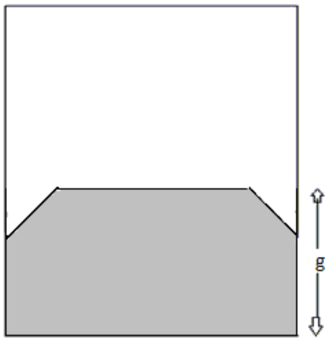

Figure 2: Bottom View

The antenna is fabricated on FR4 substrate with 30 x 30 mm^2 surface area and 1.6 mm thickness. It is fed by a 50 Ω microstrip line of width 2 mm. The relative permittivity and loss tangent of the substrate is 4.4 and 0.002. The radiating patch and feed line are mounted on the top surface of the substrate and the ground plane is mounted on the bottom surface. The gap between the radiating patch and ground plane is 0.5mm.

The gap between the ground plane and radiating patch is also optimized as it acts as a matching network and improves impedance bandwidth in two bands. In addition, ground plane dimensions are also optimized to achieve the desired dual band operation as it affects the resonant frequencies and operating bandwidths in two bands. The current distribution on the patch affects the impedance characteristics of the antenna. By cutting the two notches of suitable dimensions at the two lower corners of the patch, impedance bandwidth gets enhanced. This phenomenon occurs because the two notches affect the electromagnetic coupling between the rectangular patch and the ground plane. The patch and the ground plane form an equivalent dipole antenna. The ground plane is beveled, resulting in a smooth transition from one resonant mode to another and ensuring good impedance match and stable gain over a broad frequency range. The proposed antenna can achieve high gain at low and high frequency with bevel on the ground plane.

RESULTS AND DISCUSSIONS

Figure 3 shows the reflection coefficient versus frequency. The reflection coefficient should be -9 to -50 dB for UWB. Figure 4 shows the VSWR characterisitics. The VSWR for any antenna bandwidth should be less than or equal to 2. Figure 5 and Figure 6 shows the radiation pattern in H- plane and E-plane respectively at a frequency 6.35GHz. The radiation pattern of UWB is omni-directional in H-plane and bidirectional in E-plane. Also in Figure 7 surface current

distribution is shown which is used to analyze the optimization in the radiating patch.

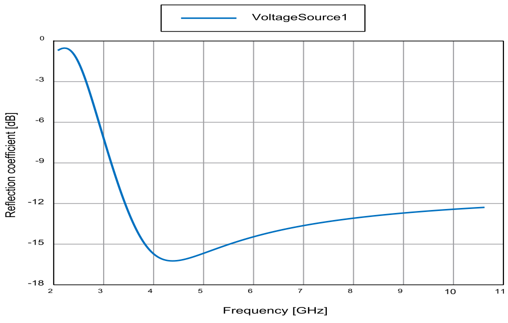

Figure 3: Reflection Coefficient versus Frequency

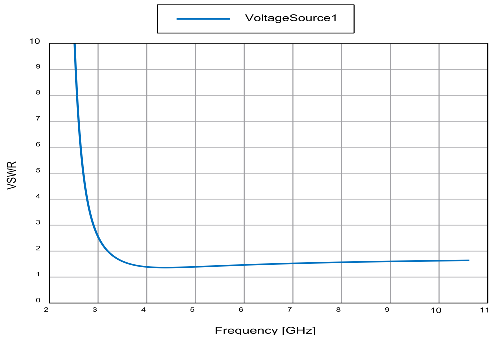

Figure 4: VSWR versus Frequency

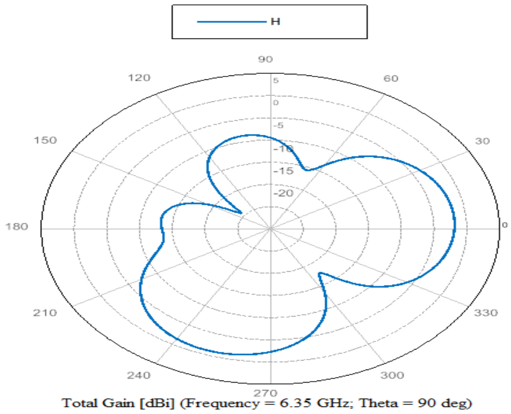

Figure 5: Radiation Pattern of H-Plane

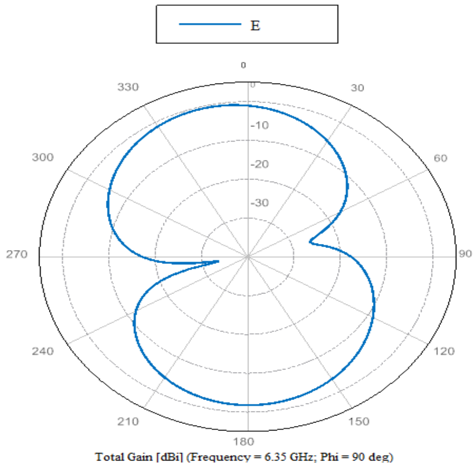

Figure 6: Radiation Pattern of E-Plane

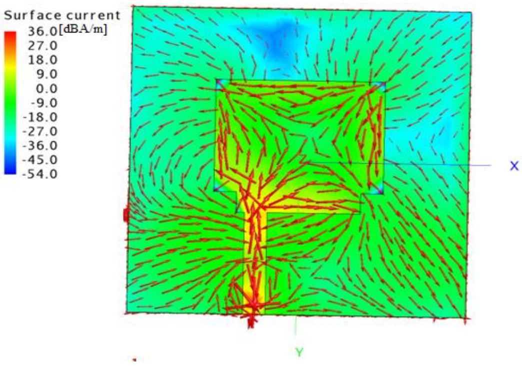

Figure 7: Surface Current Distribution

CONCLUSIONS

In this paper all the simulation results matches with the standard results of UWB. Adjusting the gap between radiating patch and ground plane, a wide impedance bandwidth is obtained. By cutting the two notches of suitable dimensions at the two lower corners of the patch, impedance bandwidth gets enhanced. Obtained radiation pattern nearly omnidirectional throughout the UWB frequency range. The proposed antenna is expected to be a good candidate for various UWB applications.

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